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Evaluation of the physicochemical and biological quality of Soueir River (Morocco)

El Mahdi Hbaiz[1], Rachid Fathallah[2], Hajar Hmima[3], Mohamed Fadli[4*]
[1, 3, 4] Laboratory of Nutrition, Health and Environment; Faculty of Sciences, University Ibn Tofail, Kenitra, Morocco
[2] Laboratory of Chemistry, Separation Process, Faculty of Sciences, University Ibn Tofail, Kenitra, Morocco

Abstract
To estimate the quality of the Soueir wadi, a small river located in the Drader - Soueir basin (In North-western Morocco) we undertook a physicochemical and biological study. This work done on River "Soueir". To our knowledge no study of the waters of this watercourse had been made before. This study involved two stations, one upstream and the other downstream of the Soueir wadi, doing a bi-monthly frequency of water samples and benthic macro invertebrates. The physicochemical characterization concerned nineteen (19) physicochemical parameters (temperature, pH, conductivity, salinity, sodium, potassium, calcium, magnesium, chlorides, sulphates, bicarbonates, orthophosphates, nitrates, nitrites, ammonium, biological oxygen demand, chemical oxygen demand, suspended solids and dissolved oxygen). The biological quality assessment is based on the calculation of the Shannon - Weaver (H ') diversity index, the equitability index (E), the Simpson index (D) and the Belgian Biotic Index (BBI). The results show that the values of the measured different physicochemical parameters are below the accepted standards with the exception of nitrates which exceed 50 mg / l in some periods of the year. Similarly, the Shannon - Weaver diversity index measure shows relatively low upstream and greater diversity downstream of the stream. The equitability indices E and D reveal an almost absolute dominance of a single group of animals: the gastropods. However, the values of the Belgian Biotic Index (BBI) indicate a fairly good water quality. These results can be explained by the combined effects of intense agricultural activity in the Drader - Soueir Basin and variations in the flow of water in the watercourse, as well as the nature of the habitat.

Keywords: oued soueir, physicochemical characterization, biological characterization, macro invertebrates, Morocco

1. Introduction
Morocco has a diversified hydrographic network crossing its different watersheds. Many researchers have carried out studies that are subject to monitoring, both in terms of variations in abiotic environmental factors and biological factors. We quote of them Benhoussa *et al*. (1988) [1], Dakki (1987) [2], Qninba *et al*., (1988) [3], El Agbani *et al*. (1992) [4], and Touabay VM (2002) [5]. However some watersheds remain little or not studied, this is the case of the Drader - Soueir basin, located in the North - West of Morocco. In fact, this course has benefited only very few studies that have focused on the hydrogeology of the Drader-Soueir basin (Combe, 1968 and 1975) [6, 7] and on the physicochemical and biological quality of Wadi Drader (Hbaiz *et al*., 2018) [8]. No previous study has investigated the physicochemical or biological quality of Soueir wadi waters.
Thus, the objective of the present work is to evaluate the physicochemical and biological quality of Soueir wadi waters, one of the Drader - Soueir basin streams and the pond « Hallofa » emissary.

2. Material and Methods
2.1 Presentation of the study area
Watershed of Oued Drader and Oued Soueir covers an area of 600 km^2 (fig. 1). This small basin is drained by two rivers. Oued Soueir is a stream, east - west direction, located north of the Drader - Soueir basin. Oued Soueir is not regularly, but sporadic measurements make it possible to fix its low average water flow, around 200 to 250 l/s. A small, rustic diversion structure is used to supply water to a portion of the Wargha agricultural estate on the right bank, downstream (Combe, 1975) [7]. The waters of this river have a dual origin: rain and groundwater from the water table. However, its flow remains much lower than that of Oued Drader. The waters of Oued Soueir are discharged into the pond "Halloufa" which has no communication with the ocean and which is isolated by a dune cordon.

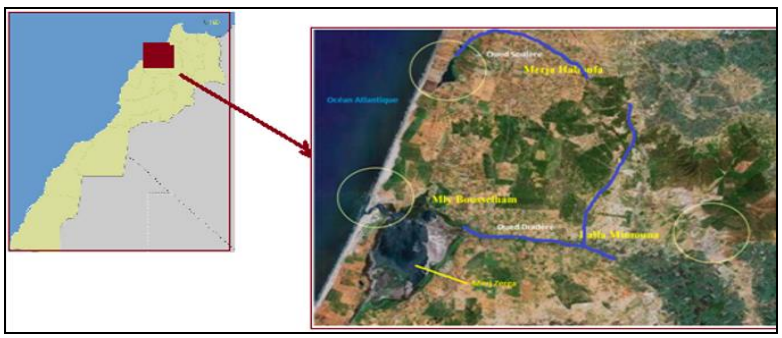

Fig 1: Location of Oued Soueir in the Drader-Soueir watershed

2.2 Sampling and analysis techniques Sampling
Sampling of water and benthic macroinvertebrates was conducted bi-monthly over a period of one year (April 2016 to April 217).

Studied physico-chemical variables
During the same study period, the general water quality of Oued Soueir was established on the basis of conventional physicochemical descriptors of water. Water samples are taken bi-monthly upstream (station S1) and downstream of Oued Soueir (station S2). As the recommendations of Thioulouse *et al*. (1997) [9] and Rodier (2009) [10], the water collected was packaged in opaque bottles and kept cold until arrival at the laboratory.

- Physical parameters
Three physical parameters were followed: water temperature, pH and conductivity. These variables were measured in site with a multi-parameter type HACH, model HQ40d.

- Chemical parameters
14 parameters were studied with the same frequency as for the physical parameters. Dissolved oxygen was measured in situ by a multi parameter HACH type HQ40d. For the other parameters, the analysis methods are those recommended by the AFNOR (1997) [11] and Rodier (2009) [10] standards.

2.3 Statistical treatment of data
The physicochemical data were apprehended in the form of gradients synthesizing several parameters, which justifies the use of multivariate analysis. A Principal Component Analysis (PCA) was performed using the ADE-4 software (Philippeau, 1986) [12] to study the variation in the spatial distribution of the physicochemical characteristics of the medium. This statistical method, which is essentially descriptive, aimed to describe the same set of data by new variables in small numbers. The PCA analysis allowed us to identify the relationships of the physico-chemical variables studied with each other and also to study the spatial distribution of the study stations (Meybeck *et al*., 1996) [13].

2.4 Method of quantitative and qualitative study of the benthic fauna
The quantitative and qualitative study of benthic macroinvertebrates is based on the analysis of the relative abundance and frequency of taxa, as well as the calculation of various indices:

- The index of Shannon and Weaver (1948) [14].
It is calculated by the following formula:

$$H' = -\sum_{i=1}^{S} p_i \log_2 p_i$$

Where;
P_i = the relative abundance of a taxon; $p_i = n_i / N$ with n_i: number of individuals of species i and N: the total effective of population.

- The index of equitability or "everness" (index of Pielou)
Equitability is the ratio, expressed in % of the true diversity over the maximum diversity.

$$\mathbf{E = H/H\ max}$$

Where;
H max = 3.322 log S
S = total number of species

- Simpson's index is calculated by the following formula:

$$D = 1 - \sum_{i=1}^{S} (p_i)^2$$

Where;
S = total number of species in the sample;
P_i: proportional abundance or percentage of importance of the species, it is calculated as follows:

$$P_i = N_i/N$$

Where;
N_i= total number of individuals of a species in the sample
N= total number of individuals of all species in the sample.

-The Belgian Biotic Index (BBI)
Which combines a quantitative measure of diversity with a qualitative measure based on the presence or absence of pollen-sensitive macroinvertebrates (Guérard, 2003) [15].

3. Results and Discussion
3.1 Physicochemical characterization of Oued Soueir waters
- Temperature

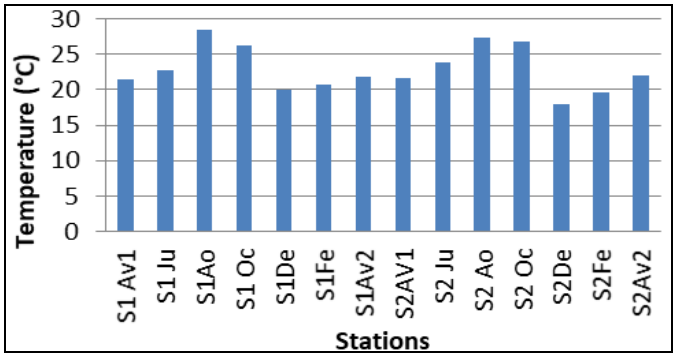

Fig 2: Spatiotemporal variation of water temperature

The temperature values recorded in the two stations S1 and S2 (Figure 2) show temporal variation attributed to the influence of the ambient temperature which is high during the summer period and low during the winter period. The minimum and maximum values are recorded in station S1 and oscillate between 18 °C recorded in December and 27.4 °C recorded in August. These variations have an influence on the dissolved oxygen content, an important parameter in maintaining the equilibrium of aquatic life.

- pH and carbonates
The measured values (Figure 3) reveal that the pH is slightly neutral to alkaline in all stations studied, both in winter and in summer. It varies between 7.45 in station S1 (April 2017) and 9.06 in station S2 (October). This fluctuation can be explained by the presence of carbonates and bicarbonates

which make it possible to buffer the water. The emergence of the water table of the basin gives rich waters of carbonates and bicarbonates. In fact, at the Drader-Soueir basin, a thick series of Upper Miocene marls (Tortonian), called the "blue marl series", after the setting of the pre-continental aquifers, covers the pre-sea formations over almost the entire basin surface. This series is thick several hundred meters as shown by oil drilling carried out in the buttonhole of Lalla-Zohra, south of the basin (Combe, 1975) [7].

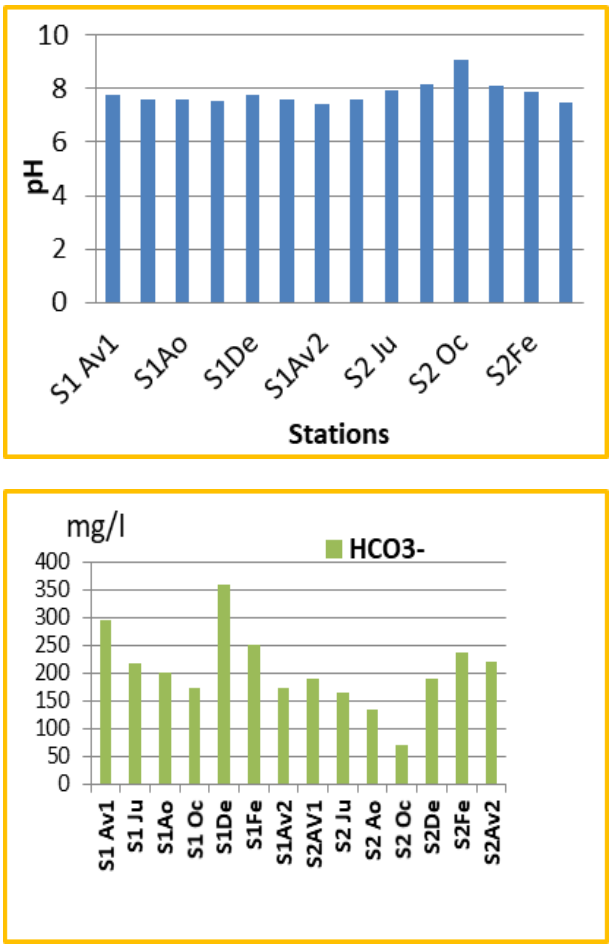

Fig 3: Spatiotemporal variation of water pH and conductivity

- Electrical conductivity and salinity

To assess the degree of mineralization of Soueir wadi water, we measured the electrical conductivity and the salinity rate. The results obtained (fig. 4) show that the electrical conductivity values fluctuate between 1036 µs/cm (October) and 1200 µs/cm in the S1 station (April 2016) and between 617 µs/cm (October) and 1440 µs/cm (December). These values are much lower than the Moroccan standard of surface water set at 2700 µs/cm (N.M, 2002) [16], thus indicating a weak mineralization of the waters. The latter may be due to the weak erosion of the bedrock by water. Note also that the conductivity of Oued Soueir waters increases between April and August. This can be explained by the decrease in water flow and the excessive use of chemical fertilizers in agriculture.

The evolution of the salinity of Soueir wadi water, represented in figure 4, shows that the salinity rate varies between 0.45 g/l (October) and 1.13 g/l (April 2016), thus answering quality requirements for irrigation water with a limit value of 2.5 g/l (FAO, 2003) [17].

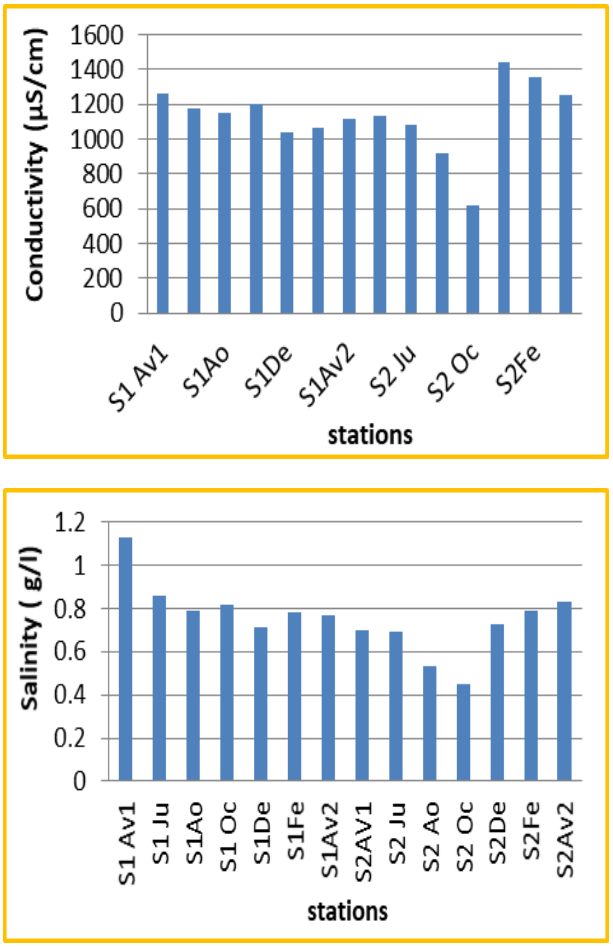

Fig 4: Spatiotemporal variation of water conductivity and salinity

3.2 Organic pollution parameters

- Biochemical oxygen demand (BOD5)

For this variable which makes it possible to evaluate the biodegradable organic matter and to deduce the degree of pollution of the water, the results obtained show that upstream of Oued Soueir, all its values found are much lower than the accepted norm (25%). mg/l) and range from 2 to 8 mg/l, indicating good water quality. Downstream, the values are between 4 mg/l, recorded in June, and 38 mg/l measured in December. This latter value therefore exceeds the limit value and indicates organic pollution of domestic origin.

- Chemical oxygen demand (COD)

The evaluation of the COD, a parameter which makes it possible to evaluate the quantity of non-biodegradable materials, shows that the values recorded in the station S1 are low and do not exceed 15 mg/L. In contrast, in station S2 is higher and exceeds the accepted standards (40 mg/l). The values recorded range from 61 mg/l, recorded in December, to 47 mg/l recorded in February. It should be noted that the high oxygen demand could be explained by water contamination by domestic wastewater from the region.

- Suspended matter (SM)

The suspended matter represents all the mineral and organic particles contained in the water. It depends on the nature of the lands crossed, the season, the rainfall, the flow regime, the nature of the discharges, etc. (Rodier, 2009) [10].

The spatio-temporal evolution of suspended matter contents

(SM), shown in Figure 5, shows variations in the concentrations of suspended matter. The values recorded in station 1 are between 2 mg/l (December) and 19 mg/l (April). Downstream of Oued Soueir (S2), the recorded values oscillate between 8 mg/l (June) and 154 mg/l (December), they are very weak during the dry period and slightly high during the humid period of the year These levels of suspended solids in Oued Soueir remain well below the Moroccan standard of 1000 mg/l (NM, 2002) [16]. These results can be attributed to low runoff and low erosion of the watershed and low organic waste discharges.
Similarly, Figure 5 shows the existence of a correlation between the oxidizable organic matter (COD) and the suspended matter (SM), which gives us information on the organic character of the suspended matter.

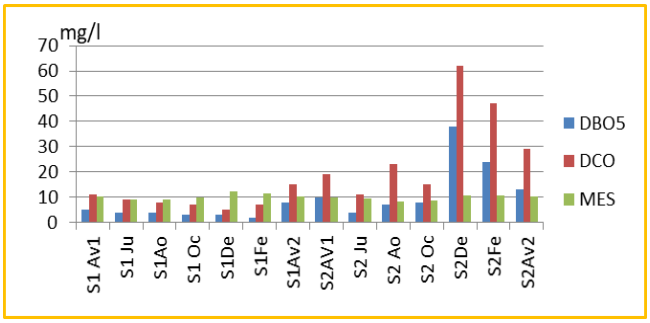

Fig 5: Spatio-temporal variation of the values of BOD5, COD and SM in water

- Dissolved oxygen

Oxygen is an excellent indicator of water quality. Its value provides information on the degree of pollution and consequently on the degree of self-purification of a watercourse.
The results (Figure 6) show spatiotemporal variations of the dissolved oxygen content in the water. Upstream of the stream, the recorded values are between 8.89 mg/l (June) and 12.55 mg/l (December). Downstream, the values range from 8.25 mg/l (October) to 10.73 mg/l (February). Overall, oxygen levels are higher during the wet period than during the low water period; however, in terms of quality standards, the waters of Oued Soueir are of good quality. Changes in dissolved oxygen levels can be explained by the decrease in water temperature, since cold water contains greater amount of dissolved oxygen than hot water (Hébert and Légaré, 2000) [18]. During the summer, the warming of the water and the decrease in the flow of the Wadi cause a decrease in dissolved oxygen dissolution (Makhoukh *et al*., 2011). Similarly, dissolved oxygen is reduced by the activity of bacteria by decomposing the organic matter present (Fekhaoui and Patee, 1993) [19].

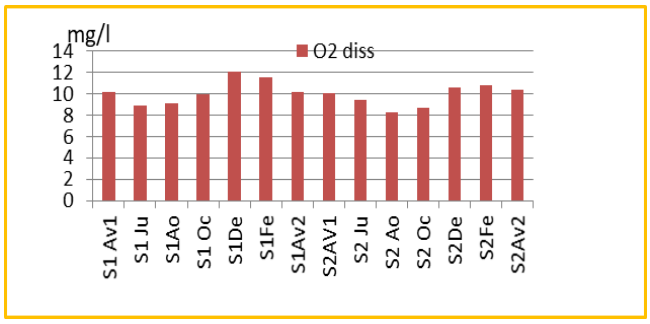

Fig 6: Spatiotemporal variation of the values of dissolved oxygen

3.3 Other chemical parameters

-Chlorures

Chlorides are often used as a pollution index. They influence aquatic fauna and flora and plant growth. The concentrations of chloride ions detected in the waters of Oued Soueir (Figure 7) range from 88 mg/l (April 2016) to 132 mg/l (October) in the station and from 94 mg/l (December) to 137 mg/l (October) in stations 2. These recorded values are all well below the Moroccan standards set at 750 mg/l (NM, 2002) [16].

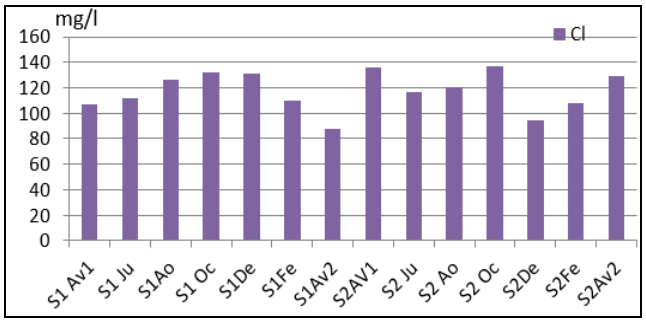

Fig 7: Spatiotemporal variation of chloride concentrations

- Nitrogen compounds and orthophsphates

The nitrogen forms studied are: ammoniacal nitrogen (NH4+), nitrites (NO2- and nitrates (NO3-).

Ammonia nitrogen

Ammonia nitrogen is a water-soluble gas. It is a good indicator of the pollution of rivers by urban effluents. In surface waters, it comes from nitrogenous organic matter and gaseous exchanges between water and the atmosphere (Chapman *et al*., 1996). The ammonium contents recorded vary between values below the detection limit (≤ 0.1 mg / l) and 1.65 mg/l measured in station 1 and 1.84 mg/l in station S2. In the waters studied, ammonium ion concentrations are high, reflecting a process of incomplete degradation of organic matter and degradation of water quality.

Nitrites

The nitrite ion (NO2-) is easily oxidized to nitrate ion, it is rarely present in significant concentration in natural waters. The results show nitrite contents of less than 0.1 mg/l.

Nitrates

Nitrate ion (NO_3^-) is the main form of combined nitrogen found in natural waters. It constitutes the final stage of the oxidation of nitrogen. Nitrate concentrations in natural waters range from 1 to 10 mg/l.
Figure 8 shows the spatiotemporal variation of nitrate levels in the studied waters. Upstream of the river, generally high concentrations, exceeding Moroccan and international standards (50 mg/l) during the month of October (163 mg/l) and the month of April 2017 (100 mg/l). Downstream, the recorded values are higher during the winter period (132 mg/l in December and 104 mg/l in February). The increase in nitrate levels in Oued Soueir waters can be attributed to the leaching of fertilizers used in agricultural soils located in the Drader Soueir basin.

Orthophosphates

The results (Fig. 8) show that the orthophosphate concentration in water ranges from 0.2 mg/L to 1.2 mg/L. These levels, sometimes exceeding the Moroccan standard

(1 mg/l), may be the cause of eutrophication observed especially upstream of the watercourse, since phosphorus is a biogenic element essential for the growth of algae.

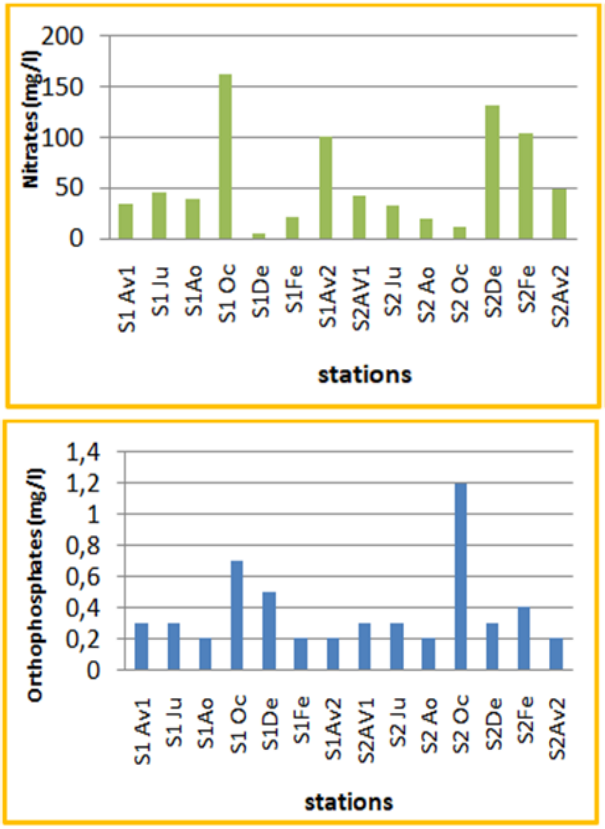

Fig 8: Spatiotemporal variation of nitrate concentration in water

- Calcium and magnesium

Figure 9 shows that limestone concentrations in the waters studied are high. They vary between 122 mg/l and 155.6 mg/l in station 1 and between 70 mg/l and 130 mg/l in station 2. These high values show that they are calcareous waters.

Magnesium concentrations in water range from 7.5 mg/l to 13.8 mg/l in Station 1 and from 7.3 mg/l to 14 mg/l in Station 2.

Note that in water, the calcium and magnesium concentrations depend essentially on the nature of the lands crossed. The recorded results can be explained by the richness of the soils of the Drader - Soueir basin in these chemical elements. Indeed, these soils are formed from marly mother rocks.

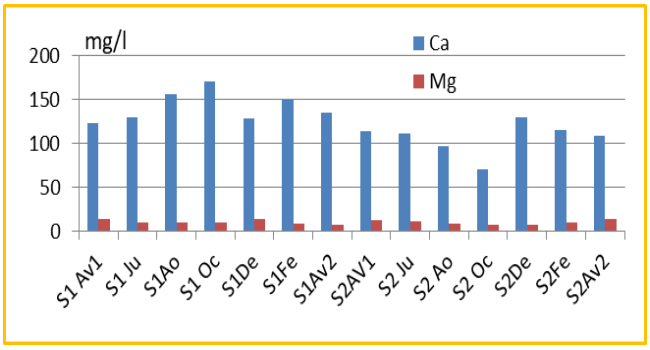

Fig 9: Spatiotemporal variation of calcium and magnesium contents in water

- Sulphates

With regard to sulphates, Oued Soueir waters are less loaded (Figure 10). Levels are below 250 mg/l, indicating that these waters are not polluted (WHO, 2000) [19].

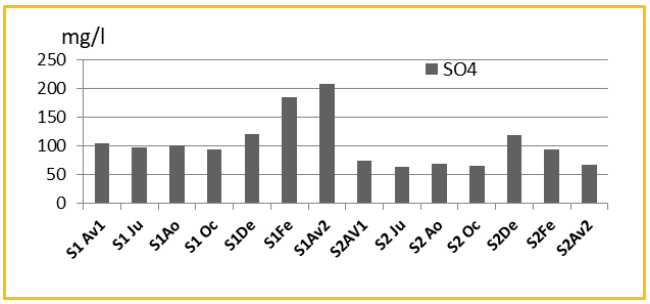

Fig 10: Spatiotemporal variation of sulphates

- Sodium and potassium

The results (Figure 11) reveal, upstream of the watercourse (S1), sodium concentrations ranging between 60 mg/l (October) and 95 mg/l (April 2017), and Downstream (S2) values range from 54 mg/l (October) to 92.5 mg/l (April 2016).

Potassium levels in the studied waters ranged between 1.8 mg/l and 5.1 mg/l upstream (S1) and between 2.6 mg/l and 5.4 mg/l downstream of Oued Soueir (S2). The increase in potassium content from upstream to downstream of Soueir is explained by the use of chemical fertilizers in crops and by soil leaching.

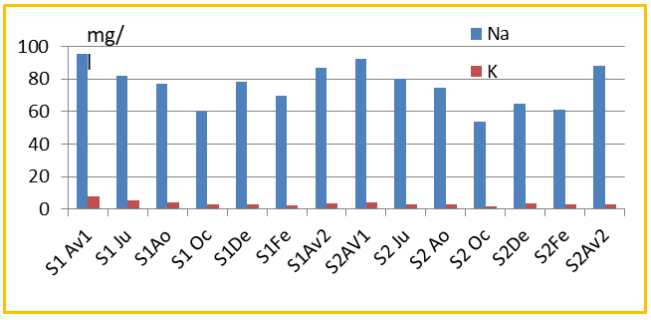

Fig 11: Spatiotemporal variation of sodium and potassium concentrations in water

3.4 Spatio-temporal typology of the physicochemical quality of Oued Soueir water

To establish a relationship between the different physicochemical parameters, a multivariate statistical analysis by the Principal Component Analysis (PCA) was applied to all the measured parameters.

The results of this analysis revealed that most of the information is explained by the first two factorial axes. The eigenvalues of the two axes C_1 and C_2 as well as their contribution to the total inertia are shown in Table 1. The two axes taken into account to describe the correlations between the variables related to spatial structures, alone hold 56.41% total information with respectively 33.23% for axis 1, 23.18% for axis 2.

Table 1: Eigenvalues of the axes C_1et C_2

	C_1	C_2
Eigenvalues	6,3147	4,4048
Variability (%)	33,2355	23,1829
% accrued	33,2355	56,4184

Table 2: Correlations between variables and factors

Variables	C_1	C_2
pH	-0,7854	0,2515
WT (Water temperature)	-0,6723	-0,4022
Cd (condctivity)	0,8116	0,4303
Salin (Salinity)	0,8094	-0,1886
Ca (Ca++)	0,5288	-0,0002
Mg (Mg++)	0,4371	-0,5351
Na (Na+)	0,6194	-0,5762
K (K+)	0,5544	-0,3141
Cl (Cl-)	-0,5414	-0,4624
SO_4^{2-}	0,4644	0,1099
HCO_3^-	0,7483	-0,2472
NO_3^-	0,2146	0,7035
NH_4^+	-0,7584	0,2282
NO2	-0,0813	0,3574
$H2PO_4^-$	-0,7660	0,1065
DBO5	0,1678	0,9012
DCO	0,1370	0,8760
SM (Suspended matter)	0,1783	0,8893
O2dis (dissolved oxygen)	0,5815	0,1410

The analysis of figures number 12, 13 and 14 shows:

- The axis 1 is expressed towards its positive pole by the COD, the BOD5, SM and the nitrate content, showing an increasing gradient of pollution parameters from upstream to downstream.
- The axis 2 is defined towards its positive pole by the dissolved oxygen, the ions sodium, calcium, magnesium, the carbonates, the sulphates, the conductivity and the salinity which have good correlations between them. This same axis is expressed towards its negative pole by the pH, the orthophosphates, the ammonium and to a less degree the chlorides. These results reveal a growing gradient of the mineralization of Oued Soueir waters. These results reflect a slight degradation of the water of Oued Soueir from upstream to downstream.

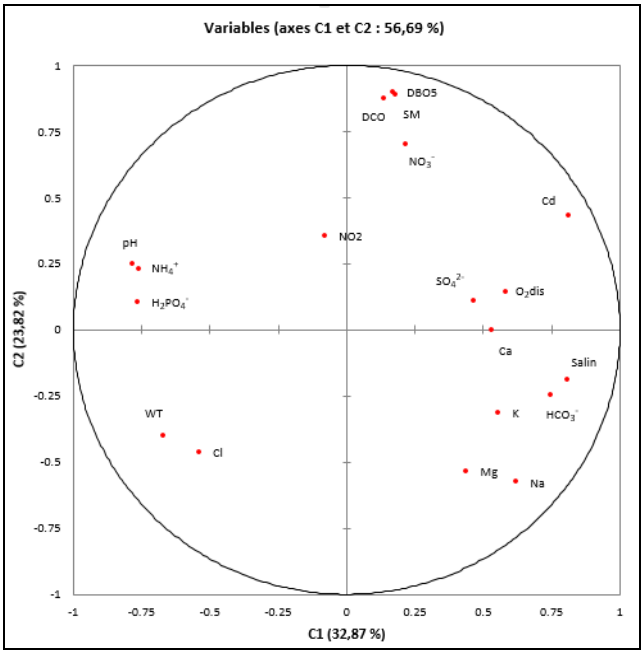

Fig 12: Representation of the variables measured in the factorial plane C_1 x C_2.

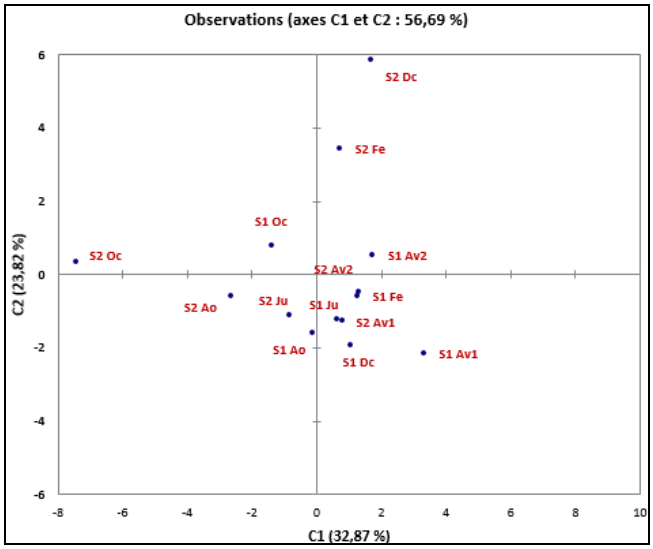

Fig 13: Representation of the stations in the factorial plane C_1 x C_2.

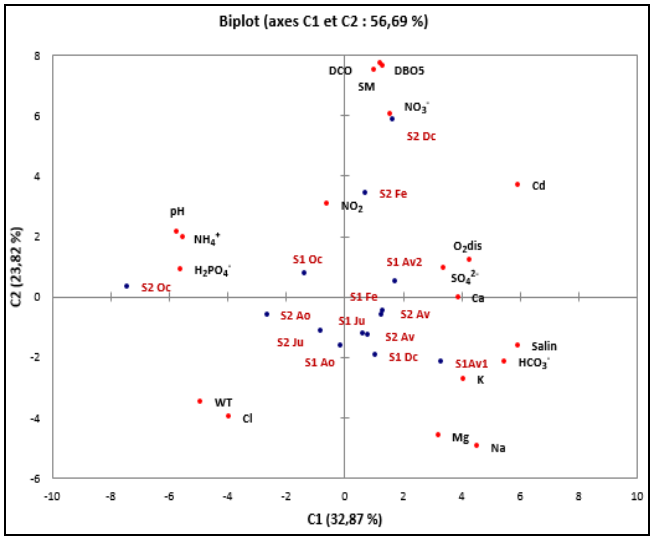

Fig 14: Correlation between the variables measured in the factorial plane C_1 x C_2.

3.5 Assessment of the biological quality of Oued Soueir waters

Taxonomic richness and frequency

The analysis of the taxonomic richness (Table 1) shows that station S1 has a cumulative number of taxa (10) which is much smaller than that of station S2 (18). This observed difference is attributed, on the one hand, to the reduced width of the upstream stream bed, which increases the flow velocity of water from small springs, and to the absence of tributaries that can shelter a diversified fauna on the other hand. Downstream of Oued Soueir, the bed is wider and has an abundance of vegetation and water, favoring the development of wildlife.

From a temporal point of view, the highest number of taxa is recorded in the samples taken in April and June. This could be explained by the favorable conditions for organism developments during this period (water availability, water temperature, dissolved oxygen, etc.).

Table 3: Results of the Fauna Inventory and Calculation of Biological Indices (H ': Diversity index of Shannon and Weaver; BBI: Belgian Biotic Index)

Stations	**S1**						**S2**					
Prélèvements	1	2	3	4	5	6	1	2	3	4	5	6
Taxons												
Cl. INSECTA												
O.Trichoptères												
Leptoceridae		1						1	1			
Odontoceridae	2						1	2				
O. Ephemeroptera												
Ephemeridae	1	1					2	1		1		1
Baetidae							1	2	2			1
O. Odonata												
Lestidae							2	2	1			1
Libellulidae	2	1	1		1	1	3	2	2	1	1	2
O. Heteroptera												
Notonectidae	1	2		1		1	3	1	1			1
Hydroptilidae							2	2	1			1
O. Coleoptera												
Dytiscidae	1						2	2		1		1
Elmidae							1	2	2			
Sphaeridiidae				1			1		1			
O. Dipteria												
Tipulidae										1		
Chironomidae									1	1		
Cl. GASTEROPODI												
O. Prosobranchia												
Physidae	8	7	7	5	3	4	2	3	1	1	2	4
Lymnaeidae	23	21	18	12	11	14	12	15	16	10	4	5
Cl. BIVALVES												
O. Eulamellibranchia												
Syphridae							2	2	3	2		2
Cl. OLIGOCHETES												
O. Prosopores												
Lumbricidae	3	5	6	4	2	2	2	3	3	2	1	1
Cl. ARACHNIDES												
O. Hydracarina												
Hydrachnidae		1	2	1				2	2	1		
Total	41	39	32	24	17	22	36	42	37	21	8	20
Nb de taxons	8	8	5	7	4	5	14	15	14	10	4	11
H'	1.27	1.42	1.23	1.35	0.99	1.09	2.12	1.96	2.07	1.77	1.21	1.85
E	0.43	0.48	0.54	0.49	0.51	0.48	0.57	0.51	0.56	0.55	0.62	0.55
D	0.64	0.71	0.60	0.73	0.54	0.998	0.998	0.99	0.8	0.962	0.98	0.87
IBB	7	6	4	5	3	4	7	8	7	5	3	6

The calculation of frequency of occurrence F (all samples taken at each station) gave the following results:

- Very common taxa (80 ≤ F ≤ 100%): Libellulidae, Physidae, Lymnaeidae, Lumbricidae
- Frequent taxa (50 ≤ F < 80%): Ephemeris, Notonectidae and Hydrachnidae.
- Quite frequent taxa (20 ≤ F < 50%): Leptoceridae, Odontoceridae, Beatidae, Lestidae, Hydroptilidae, Dytiscidae and Syphridae.
- Rare taxa (5 ≤ F < 20%): Tipulidae and Chironomidae.
- Accidental taxa (F < 5%): Absent.

Study of diversity

Upstream of Oued Soueir, the average values of the diversity index of Shannon and Weaver are between 0.99 and 1.42 reflecting a low diversity. While downstream, the values of the Shannon - Weaver index exceed the value 2 between April and August reflecting good specific diversity. This is explained by the habitat that is favorable for the development of the majority of macroinvertebrates. There is also a significant decrease in the diversity and a decrease of stands during the winter period, attributed to conditions that become unfavorable to the development of macroinvertebrates.

The study of the spatio-temporal evolution of the Shannon - Weaver index (H ') and the equitability index (E), represented in Figure 15, show the same trend in the upwelling of Soueir wadi (station 1), whereas downstream the values of the Shannon - Weaver index are high, while the equitability remains stable.

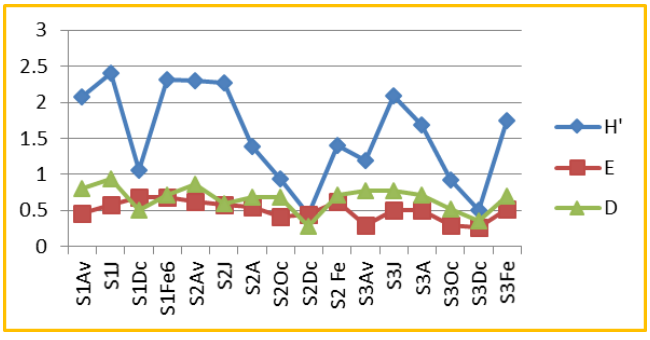

Fig 15: Variation of the Shannon index (H '), Equitability (E), and the Simpson Index (D)

To account for both species richness and fairness in a single number, we have to calculate Simpson's index (D). It measures dominance in a benthic community. The results obtained are shown in Figure 15.

Also, data in Figure 15 show that:

- Upstream of the Sueir Simpson's index is close to 0.7, reflecting the presence of species rather large but their distribution is not fair.
- Downstream, Simpson's index approaches 1, indicating an almost absolute dominance of a single group of animals: the gastropods.

To classify the Oued Soueir waters from biological data, the Belgian Biotic Index (BWI) was determined for both stations (Appendix 1). The highest values are recorded during the spring. Thus the values of the biotic index for the months of April and June are respectively 7 and 6 for station 1, and 7 and 8 for station 2.

Referring to the water classification table (Appendix 2), it can be said that the waters of Oued Soueir are not very polluted.

4. Conclusion

The physicochemical characterization of Oued Soueir waters shows that the contents of the different physicochemical parameters are lower than the accepted standards with the exception of nitrates which exceed, largely 50 mg/l in some periods of the year.

The statistical treatment of the results by the PCA reveals a growing gradient of organic pollution parameters and nitrates from upstream to downstream indicating a slight degradation of the water. These data can be explained by the combined effect of intense agricultural activity in the Drader - Soueir basin and variations in water flow.

Similarly, the biological study of the studied river reveals a spatiotemporal variation of the benthic invertebrate macrofauna. Indeed, the measure of diversity, via the Shannon Weaver index and the equitability index, shows a relatively low diversity upstream and more important downstream of the stream, with gastropod dominance. However, the values of the Belgian Biotic Index (BBI) indicate a fairly good quality of the water of Oued Soueir. But, note that the distribution of macroinvertebrates may be influenced by other factors such as the nature of the substrate and habitat, which may affect biotic indices.

5. References

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